# EMERGENCY RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM REPORT


**Reporting Period**
January 2010 to December 2010

Nuclear Response and Emergency Environmental Surveillance Section
Division of Waste Assessment & Emergency Response
Bureau of Land and Waste Management

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**LIST OF ACRONYMS** (used in this report)

| | |
|---|---|
| **CFM** | Cubic feet per minute |
| **CNS** | Catawba Nuclear Station |
| **CR** | Cross road |
| **DHEC** | Department of Health and Environmental Control |
| **EPZ** | Emergency Planning Zone |
| **EREM** | Emergency Radiological Environmental Monitoring |
| **ES** | Environmental Sampling |
| **HBRNS** | HB Robinson Nuclear Station |
| **HPGe** | High Purity Germanium |
| **Jct** | Junction |
| **KG** | Kaleidograph |
| **LPM** | Liters per minute |
| **mR/yr** | Milliroengten per year |
| **mrem/yr** | Millirem per year |
| **NORM** | Naturally Occurring Radioactive Material |
| **NPP** | Nuclear Power Plant |
| **NRC** | Nuclear Regulatory Commission |
| **NREES** | Nuclear Response and Emergency Environmental Surveillance |
| **ONS** | Oconee Nuclear Station |
| **pCi/m$^3$** | Picocuries per cubic meter |
| **QAPP** | Quality Assurance Project Plan |
| **RR** | Railroad |
| **SOP** | Standard Operating Procedure |
| **TLD** | Thermoluminescent Dosimeter |
| **USEPA** | US Environmental Protection Agency |
| **VCSNS** | VC Summer Nuclear Station |

## 1.0 INTRODUCTION

The State of South Carolina is home to four commercial nuclear power reactor stations. They are located in Darlington, York, Oconee and Fairfield Counties. These commercial stations, licensed by the Nuclear Regulatory Commission (NRC), are mandated to conduct routine environmental monitoring to measure any off-site impacts to the public and the environment from facility discharges. In addition to the monitoring conducted by the commercial stations, the South Carolina Department of Health and Environmental Control's (DHEC) Nuclear Response and Emergency Environmental Surveillance Section (NREES) provides periodic radiological environmental monitoring around these commercial facilities. This Emergency Radiological Environmental Monitoring (EREM) project report describes the type and frequency of sample collection, as well as quality control, reporting methods and equipment used.

The EREM project provides DHEC with an environmental baseline for several parameters when collecting air samples in the event of a radioactive material release at one of the commercial nuclear stations. These pre-established sampling locations would be used to assist DHEC in determining the extent of contamination from an event, as well as evaluating the radiological population dose.

## 2.0 PURPOSE

The purpose of the EREM project is to provide emergency environmental surveillance monitoring of commercial nuclear stations in South Carolina and to determine if there is a potential for offsite impact from each station's activities to the environment and human health. The project also serves to establish baseline trends for several radiological parameters as a referenced sampling network in the event of an accidental release. Findings documented in this environmental report will be published and made available for public dissemination.

## 3.0 OBJECTIVES

The DHEC NREES pursues three primary objectives:

1. To collect and analyze radiological environmental samples via the air pathway to provide background data on natural radioactivity and/or man-made sources of radioactivity in the vicinity of South Carolina's commercial nuclear facilities

2. To establish baseline data to discern and adequately assess any data anomalies and/or trends that may be indicative of an accidental release during nuclear plant operations to the environment and its impact on public health.

3. Develop an annual environmental report summarizing the results of these activities.

# 4.0 METHODOLOGY

The NREES staff is responsible for all aspects of collection and transportation of samples to appropriate laboratories for analysis. This section provides specific information pertaining to sampling methods, sample type, sample frequency, sample analyses, and sampling locations.

## 4.1 SAMPLE TYPE

Air particulate samples and thermoluminescent dosimeters (TLD) are collected quarterly. Air particulate samples consisting of charcoal cartridges and particulate filters are used to detect any airborne radiological contamination. TLDs are collected to measure direct radiation exposure from the facilities. These samples will provide the basis for monitoring the atmospheric exposure pathway.

## 4.2 SAMPLE FREQUENCY

The air sampling media are deployed and collected one week per month at each commercial nuclear station. The selection of the sampling week is random. However, for future comparison, the initial start days of the week, have been predetermined to align DHEC's sampling regime, with that of the SC nuclear stations. The predetermined sample collection schedule is as follows:

**Table 4.1 Predetermined Air Particulate Sampling Schedule**

| Nuclear Stations | Collection Schedule |
|---|---|
| Oconee | Mondays |
| HB Robinson | Mondays |
| Catawba | Tuesdays |
| VC Summer | Wednesdays |

TLDs are collected on a standard quarter.

## 4.3 SAMPLE ANALYSIS

The DHEC Radiochemistry Laboratory in the Division of Analytical & Radiological Environmental Services provides the air particulate sample analyses for this project. The samples are analyzed for alpha, beta, and gamma-emitting radionuclides using standard EPA approved methodology (EPA 900.0 and EPA 901.1). The TLDs are sent to a National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory for processing.

### 4.4 SAMPLE LOCATIONS

Sample locations are based primarily on local population centers and annual prevailing wind directions. Air particulate samples are collected at two locations around each commercial nuclear station.

Twelve (12) TLDs are strategically placed around each nuclear station. One duplicate TLD is co-located with an existing TLD location per nuclear station. In addition, background and transit (trip blank) TLDs are used and read along with each set of field TLDs to estimate local site natural background and transit exposures, respectively. The background TLDs are placed in the field in an area with no prevailing wind relative to the nuclear station of interest. A control TLD has been used to determine the radiation exposure received during storage and transit to and from Global Dosimetry Solutions, Inc. Until transport, this control TLD is kept in a shielded container at DHEC. Some TLD locations denoted in the Tables in Section 8.0 are not part of the original NRC/DHEC sampling network and subsequently, no historical data exists for these locations. Maps depicting sampling locations and descriptions for each commercial nuclear facility are also provided in Section 8.0.

### 4.5 ENVIRONMENTAL SAMPLING

In the context of EREM, environmental sampling (ES) is the collection and analysis of ambient air samples for radiological parameters that would confirm any significant release from a facility. The application of ES usually involves two stages: baseline sampling and routine sampling. Baseline (pre-operational) sampling is performed to establish a reference 'environmental signature', and routine (operational) sampling is subsequently performed to obtain data that can be compared for consistency with the established baseline environmental signature and the declared operations.

### 4.6 STATISTICAL ANALYSIS

Statistical analysis and data reduction of the sampling data are performed. For discussion purposes, the mean, maximum and minimum values of the data results are used to assess the impact of any planned or accidental release of radioactive materials in the environment.

## 5.0 RADIOLOGICAL LABORATORY COUNTING SYSTEMS

The counting systems used by DHEC Radiochemistry Laboratory for radiological analysis are outlined below.

### 5.1 GAS FLOW PROPORTIONAL COUNTERS

The following systems are used for the analysis of gross alpha and beta in water, air filters, soil, and vegetation, as well as radium 226, radium 228, techetium-99 and uranium in water:

A Tennelec LB5100 gas flow proportional counting system that uses a 2.25-inch detector having an 80 microgram/$cm^2$ detector window with an automatic changer with a capacity of 50 samples.

Three Protean gas flow proportional counting systems each using a 2.25-inch detector. They have an 80 microgram/$cm^2$ detector window with an automatic changer with a capacity of 50 samples.

A Protean WPC9604 multichannel gas flow proportional counting system using eight 2.25-inch detectors. It has 80 microgram/$cm^2$ detector windows with the capability of simultaneously counting eight samples.

They use P-10 gas, which is a mixture of 90% argon and 10% methane.

### 5.2 HIGH PURITY GERMANIUM DETECTORS (HPGE)

These systems are used for the analysis of gamma emitting radionuclides in water, soil, vegetation, milk, swipes, air filters and air cartridges.

The fixed laboratory system consists of six HPGe detectors from various vendors. They have relative efficiencies of 40%, 42%, 54%, 57%, 90% and 95%. It utilizes Canberra's PROcount ESP software with an Open VMS platform for data acquisition and analysis.

## 6.0 QUALITY ASSURANCE ACTIVITIES

Samples are collected according to the methods described in DHEC's Environmental Investigations Standard Operation Procedures (SOPs) and Quality Assurance Manual Section 18: Radiological Monitoring. The appropriate chains of custody are used to ensure the integrity and quality of the samples. DHEC's sampling personnel are trained on the proper methods for sample collection.

The quality assurance reviews for the sampling network are conducted and documented in the following:

South Carolina Department of Health and Environmental Control (DHEC), *Standard Operating Procedure for Analysis of Environmental Samples for Gross Alpha/Beta Activity*, Section VI-N, Bureau of Environmental Services, July 2005.

South Carolina Department of Health and Environmental Control (DHEC), *Standard Operating Procedure for Analysis of Environmental Samples for Gamma Emitting Radionuclides*, Section VI-L, Bureau of Environmental Services, July 2005.

South Carolina Department of Health and Environmental Control (DHEC), *Section 3. Quality Assurance Procedures, Special Study Plans and Approvals* in Quality Assurance Management Plan For South Carolina Department Of Health And Environmental Control, Bureau of Environmental Services, Rev. 2, May 2006.

South Carolina Department of Health and Environmental Control (DHEC), *Section 19.6. Chain-of-Custody Procedures for Radiological Samples* in Quality Assurance Management Plan For South Carolina Department Of Health And Environmental Control, Bureau of Environmental Services, Rev. 2, May 2006.

South Carolina Department of Health and Environmental Control (DHEC), *Section 18. Radiological Monitoring* in Quality Assurance Management Plan For South Carolina Department Of Health And Environmental Control, Bureau of Environmental Services, Rev. 2, May 2006.

South Carolina Department of Health and Environmental Control (DHEC), *Section 4. Basic Training for New Employees Who Will Perform Field Activities* in Quality Assurance Management Plan for South Carolina Department of Health and Environmental Control, Bureau of Environmental Services, Rev. 2, May 2006.

Global Dosimetry Solutions, Inc., *Quality Assurance Manual*, Rev. 22, in Quality Assurance Plan, January 2008.

Data received from the DHEC Radiochemistry Laboratory goes through an internal verification and validation process and a review and validation process by designated NREES staff to ensure compliance with DHEC SOPs for handling and analyzing samples. The direct radiation (TLD) monitoring data undergoes a similar process.

## 7.0 ENVIRONMENTAL CONSIDERATIONS AND DATA TREATMENT

*Significant Environmental Considerations*

Conforming to the purpose and objectives of the emergency environmental monitoring program, the data analysis results per SC nuclear station are discussed in this section. The presentation of the data results reflects whether or not any significant environmental consideration had occurred during the period of January 2010 through December 2010. "Significant environmental consideration" is defined as any increasing or decreasing in levels of radioactivity (outliers) due to field equipment malfunctions, presence of isotopic anomalies, any deviation from historical or recent trends, and/or human errors such as calculation errors, sampling errors, maintenance/unusual plant event, etc.

For any data anomaly that posed an environmental consideration, an attempt to verify and explain the reason(s) behind the anomaly is pursued by examining the specific nuclear facility environmental report/data for that time period, reviewing seasonal and historical trends, checking equipment operability during that time frame, and identifying any possibility of simple human error. In addition, statistical analysis is applied to all the data results. Figures 1 through 8 are used as visual aids to identify an anomaly, if any, which

would be classified as a significant environmental consideration by definition in this report.

*Data Fluctuations (Variability) in Air Particulate Sample Analysis*

One commonality among the air sampling data results is the normal environmental tendencies of data fluctuation. Based on the trends of relevant data, the occurrence of data fluctuation in the gross beta particle activity at each facility is due to seasonal influences, difference in locations of instrumentation, shifts in weather patterns, and different settings of airflow rates per instrument.

*Treatment of Broken Air Samplers, Discrepancies in Calculations, and Sample Handling Errors*

Particulate retention on air samples varies. This variation is directly related to the fluctuation of data as seen in air monitoring figures in Section 8.

## 8.0 PRESENTATION OF THE DHEC AIR SAMPLING NETWORK RESULTS

Figures 8.1 through 8.8 are used to identify any anomaly that would warrant further environmental investigations.

## 8.1 OCONEE NUCLEAR STATION

The Oconee Nuclear Station (ONS) is a three unit pressurized water reactor complex with each nuclear reactor having an electrical output of about 922 megawatts. Oconee Nuclear Station is operated by Duke Power Company as part of the Keowee-Toxaway Project. The reactor complex is located 13 km northeast of Seneca, SC and about 40 km West of Greenville, SC. Lake Keowee was formed to serve the reactors and other power facilities of the Keowee-Toxaway Project. Unit 1 achieved initial criticality on April 19, 1973 and began commercial operations on May 6, 1973.

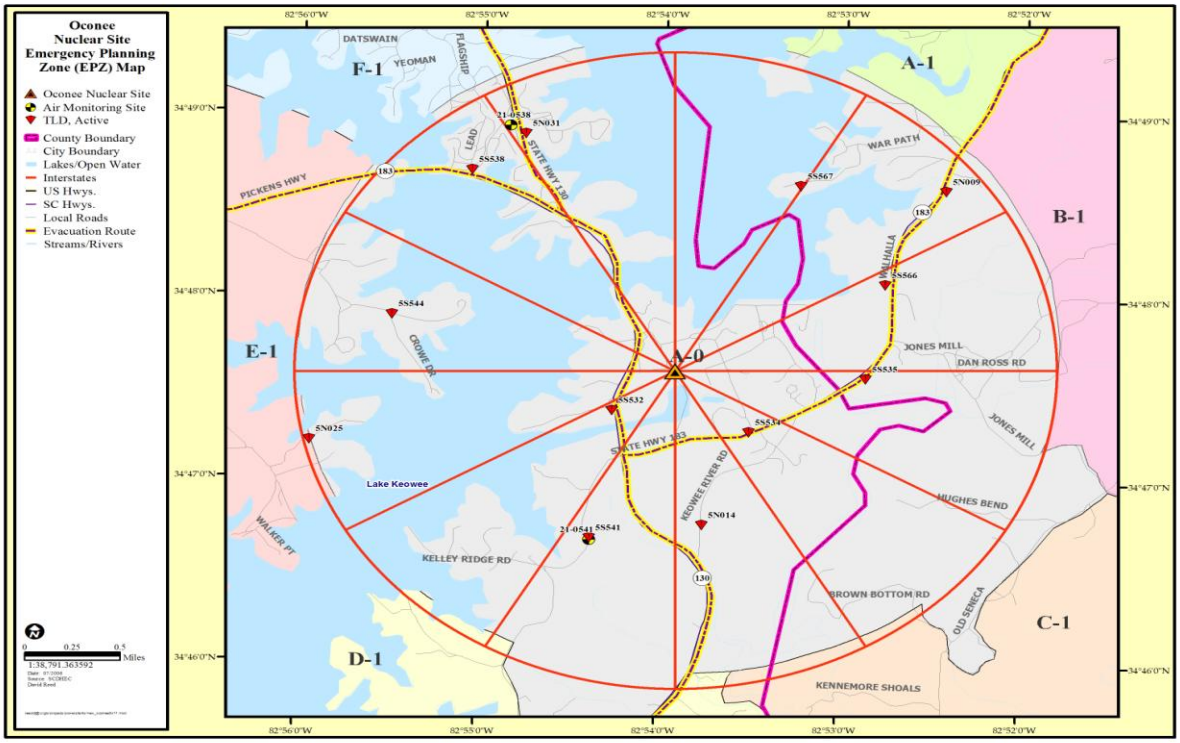



**Illustration 1 ONS Emergency Planning Zone Map with Air and TLD Sample Locations**

**Table 8.1 DHEC ONS Air Sampler Locations**

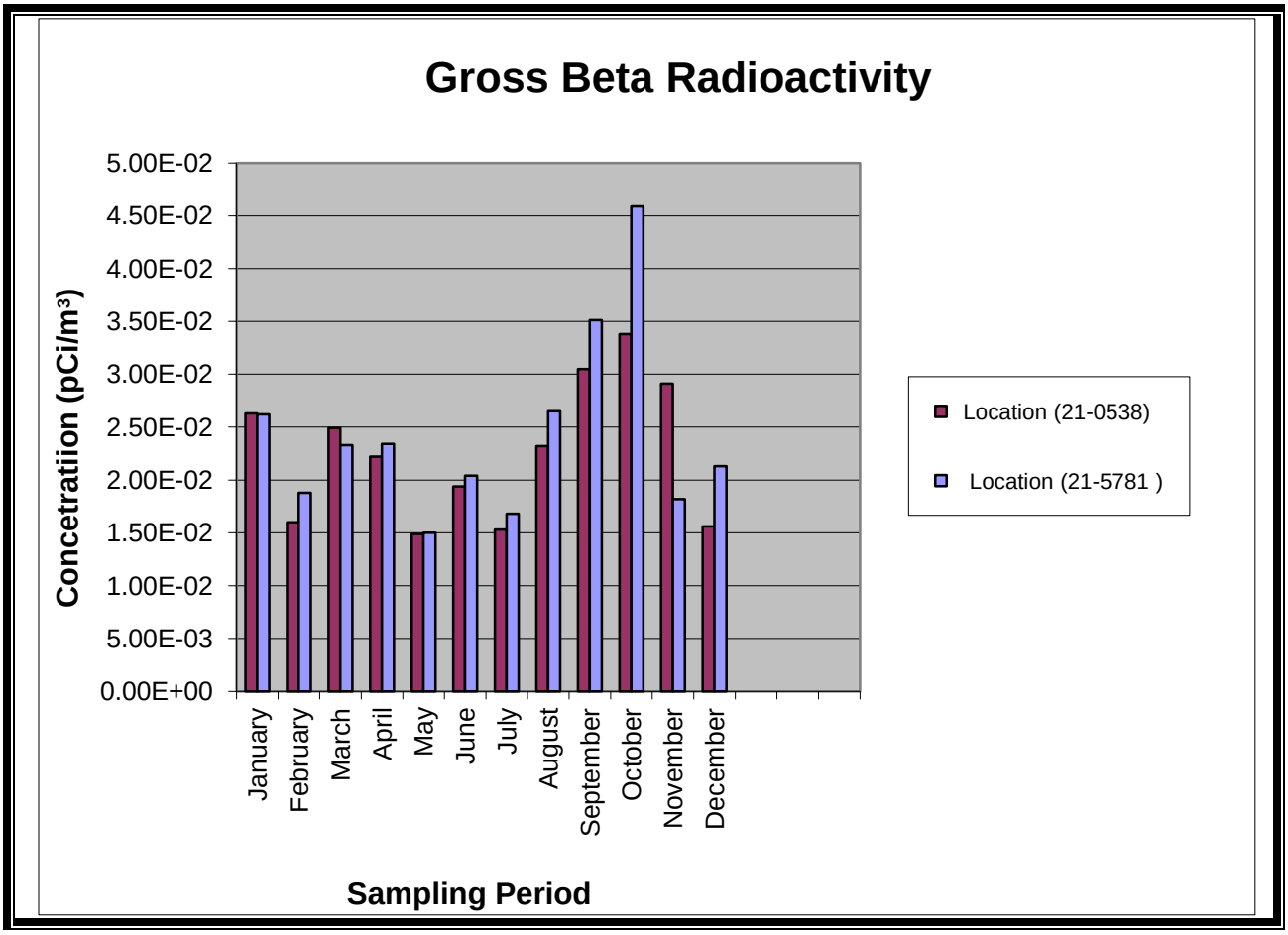
| Sample Location | Location Description |
|---|---|
| 21-0538 | Air Sampler at Keowee Subdivision waste treatment plant off SC Hwy #130 (1.8 miles WNW of ONS). |
| 21-5781 | Go North from the intersection of SC # 183 and SC#130. Go one-half mile on the SC #130 to the entrance of Duke recreation area on left |

**Table 8.2 DHEC ONS TLD Locations**

| | Sample Location | Location Description |
|---|---|---|
| * | 5N031 | McConnells Dive Services on Rt. 130 |
| | 5S567 | Warpath Landing |
| * | 5N009 | On SC#183 past small barn on Utility Pole |
| | 5S566 | Hwy. 183, 0.3 mile North of CR# 160 |
| | 5S535 | From bridge on Hwy. 183 go east 1/5mi |
| | 5S534 | From bridge on SC# 183 2nd rd on rt |
| * | 5N014 | SW on rt.6, on tree at dirt pull off |
| | 5S541 | CR# 15, 0.7 mile South of Hwy. 130 |
| | 5S532 | 0.6 mi. SSW on right side of gate on Hwy 130 |
| * | 5N025 | Go 0.3 mi on Ellenburg Rd on Utility Pole |
| * | 5S544 | Jct CR's 574 & 201 across from Church |
| | 5S538 | Keowee Key Guard Station |

* No NRC/DHEC historical data for this TLD Location

**Figure 8.1 DHEC Airborne Radiation Monitoring Data ONS**
Reporting Period: January 2010 to December 2010




**ENVIRONMENTAL CONSIDERATIONS: ANOMALIES/OUTLIERS**
ONS—Air Samplers

**1.Significant Increasing/Decreasing levels of radioactivity**: Gross Beta activity increases during the month of October(seasonal shift)

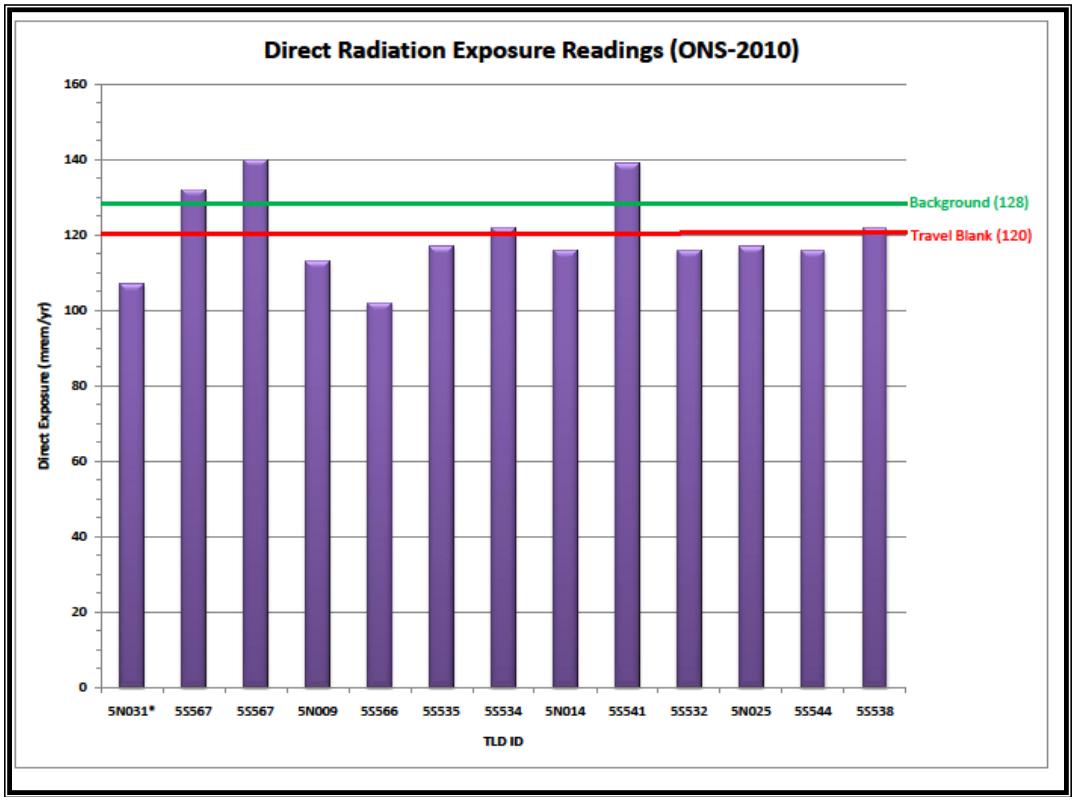
**2. Equipment Malfunctions:** NONE

**3. Weather Conditions:** NONE

**4. Deviation from historical and/or recent trends:** NONE

**5. Human errors (Calculation errors, sample handling errors):** NONE

**Figure 8.2 DHEC Direct Radiation Monitoring Data ONS**
Reporting Period: January 2010 to December 2010




**ENVIRONMENTAL CONSIDERATIONS: ANOMALIES/OUTLIERS**
*ONS—Thermoluminescent Dosimeters (TLD)*

**1.Significant Increasing/Decreasing levels of radioactivity:**

Three (3) TLD readings (5S541, 5N031, and 5S567) are above the control TLD exposure.

**2.Missing TLD(s): Sample ID 5N031** during the 2nd Quarter 2010

**3.Weather Conditions:** NONE

**4.Deviation from historical and/or recent trends:** NONE

**5. Human errors (Calculation errors, sample handling errors):** NONE

## 8.2 H.B. ROBINSON NUCLEAR STATION

The H. B. Robinson Nuclear Station (HBRNS) has a pressurized water reactor designed to produce 739 megawatts of gross power. The power reactor, operated by Progress Energy Corporation, is located in Darlington County, 4.5 miles WNW of Hartsville, SC. The reactor is located at Lake Robinson, which was impounded in the late 1950s to furnish cooling water for the existing fossil (coal) fuel power generating plant, HB Robinson Unit No. 1. Lake Robinson was formed by impounding Black Creek that flows southeastward from the site through Darlington and Florence counties and joins the Pee Dee River. The unit was declared to be in commercial operation on March 7, 1971.

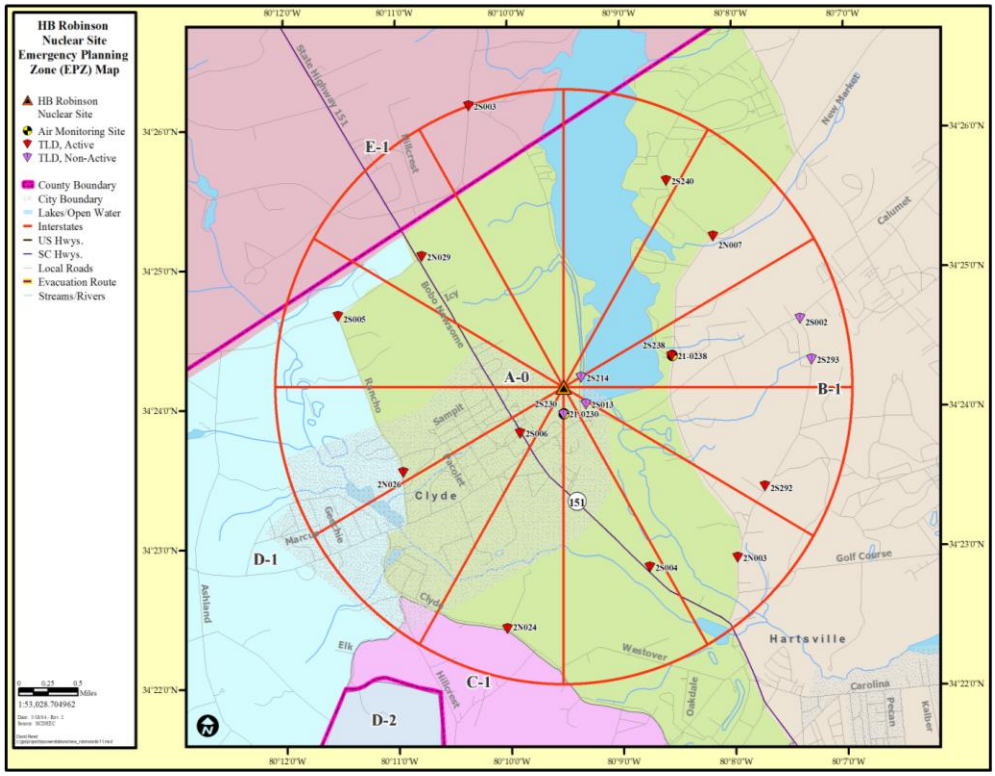



**Illustration 2 HBRNS Emergency Planning Zone Map with Air and TLD Sample Locations**

**Table 8.3 DHEC HBRNS Air Sampler Locations**

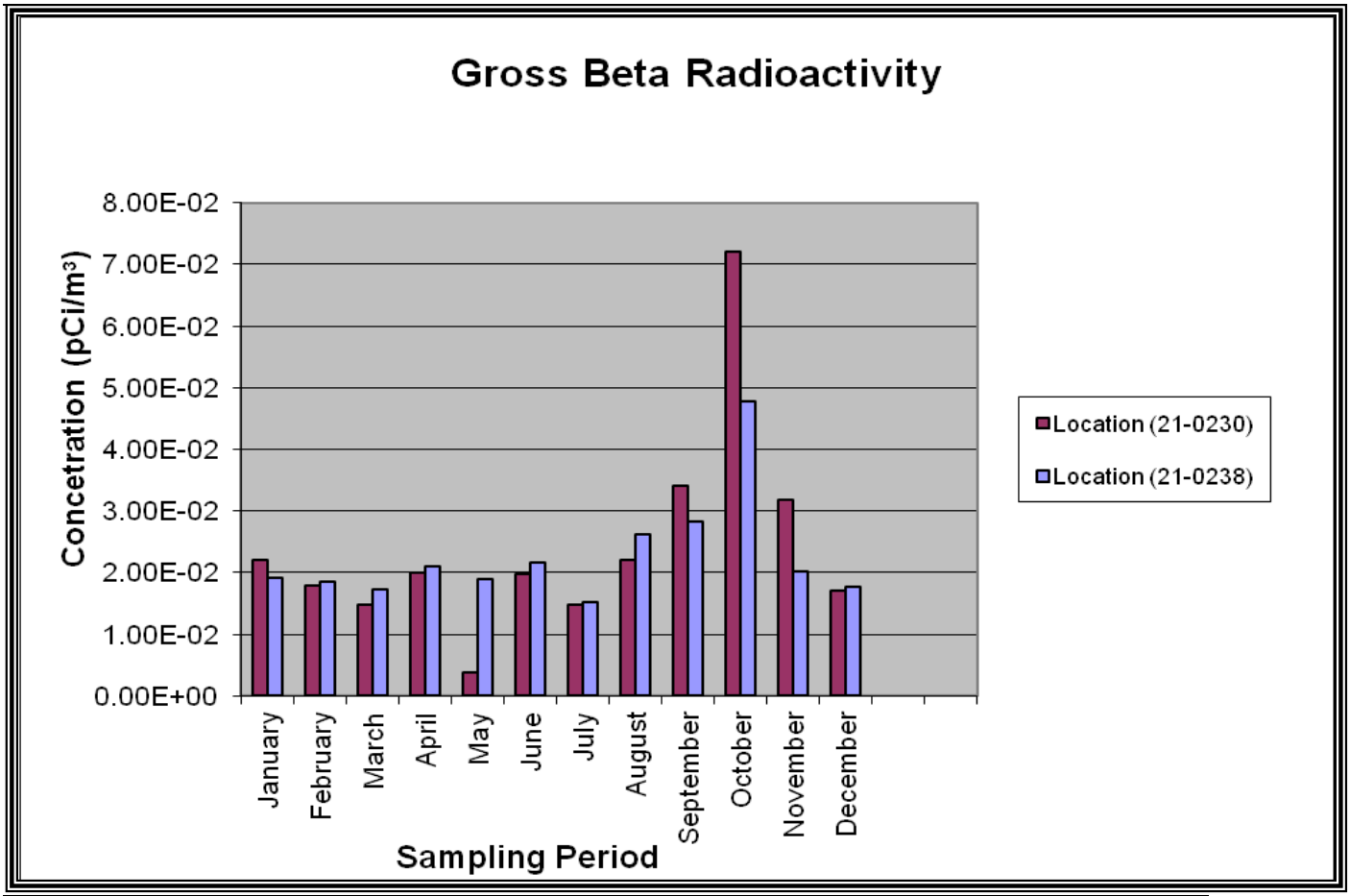
| Sample Location | Location Description |
|---|---|
| 21-0230 | In front of Visitors Center at H.B. Robinson (0.2 mile S H.B. Robinson) |
| 21-0238 | Off Darlington county #39, first left above Johnson's Marina. North of Darlington County #23 (0.8 miles E of H.B. Robinson). |

**Table 8.4 DHEC HBRNS TLD Locations**

| | Sample Location | Location Description |
|---|---|---|
| * | 2S003 | Chesterfield CR# 172 at RR |
| | 2S240 | Easterling's Landing |
| * | 2N007 | N. on Rt 39, 0.3 mi to the inters w/Rt737 |
| | 2S238 | Johnson's Landing Air Sampler |
| | 2S292 | Intersection of CR# 824 and Beulaland |
| * | 2N003 | On Utility pole by house at 1025 New Market Rd |
| | 2S004 | On SC 151 South from HBR at substation. On power pole (2.0 mile Southeast of HBR). |
| * | 2N024 | N. on Clyde Rd across from Fessional Dr |
| | 2S006 | Pine Ridge Rescue Squad Bldg |
| * | 2N026 | On Rt. 761 go 0.5 mi to Utility Pole |
| * | 2S005 | Darlington Co. #176 – 2.1mi WNW HBR |
| * | 2N029 | On Rt. 171, 0.8 mi from intersection with Hwy 151 |

** No NRC/DHEC historical data for this TLD Location*

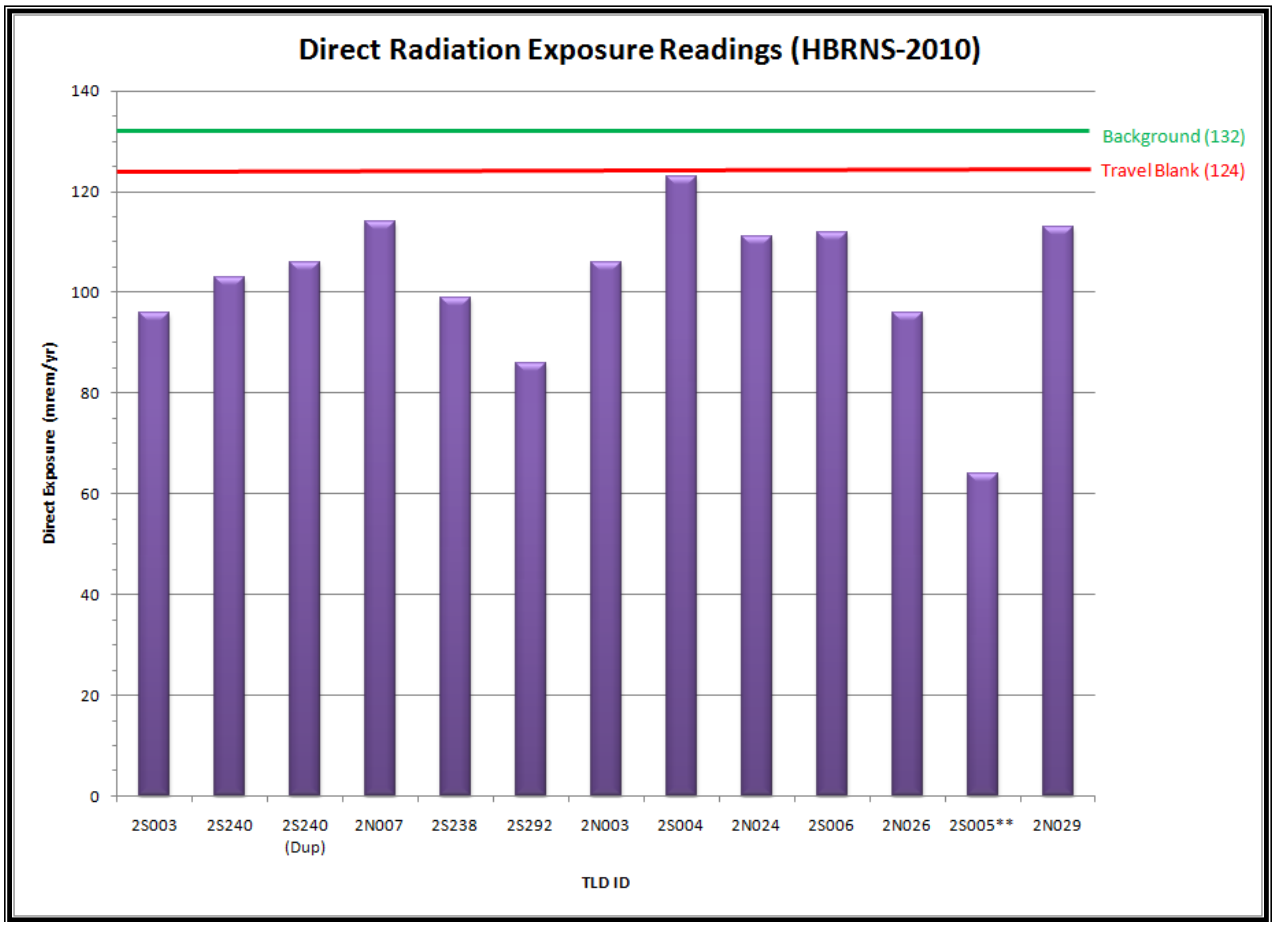
**Figure 8.3 DHEC Airborne Radiation Monitoring Data HBRNS**
Reporting Period: January 2010 to December 2010




**ENVIRONMENTAL CONSIDERATIONS: ANOMALIES/OUTLIERS**
*HBRNS—Air Samplers*

1. **Significant Increasing/Decreasing levels of radioactivity:** Gross Beta activity increases during the month of October(seasonal shift)
2. **Equipment Malfunctions**: NONE
3. **Weather Conditions:** NONE
4. **Deviation from historical and/or recent trends:** NONE
5. **Human errors (Calculation errors, sample handling errors):** NONE

**Figure 8.4 DHEC Direct Radiation Monitoring Data HBRNS**
Reporting Period: January 2010 to December 2010




ENVIRONMENTAL CONSIDERATIONS: ANOMALIES/OUTLIERS
*HBRNS—Thermoluminescent Dosimeters (TLD)*

**1. Significant Increasing/Decreasing levels of radioactivity:** NONE

**2. Missing TLD(s): Sample ID 2S005** during 1st Quarter 2010.

**3. Weather Conditions:** NONE

**4. Deviation from historical and/or recent trends:** NONE

**5. Human errors (Calculation errors, sample handling errors):** NONE

## 8.3 VC SUMMER NUCLEAR STATION

Virgil C. Summer Nuclear Station (VCSNS) has a 900-megawatt Westinghouse pressurized water reactor, located adjacent to the Monticello Reservoir near Jenkinsville, SC, is operated by South Carolina Electric and Gas (SCE&G). The site is approximately 26 miles north of Columbia, SC. VC Summer Nuclear Station achieved initial criticality October 22, 1982, reached 50% power December 12, 1982 and 100% power June 10, 1983 following a steam generator feedwater modification.

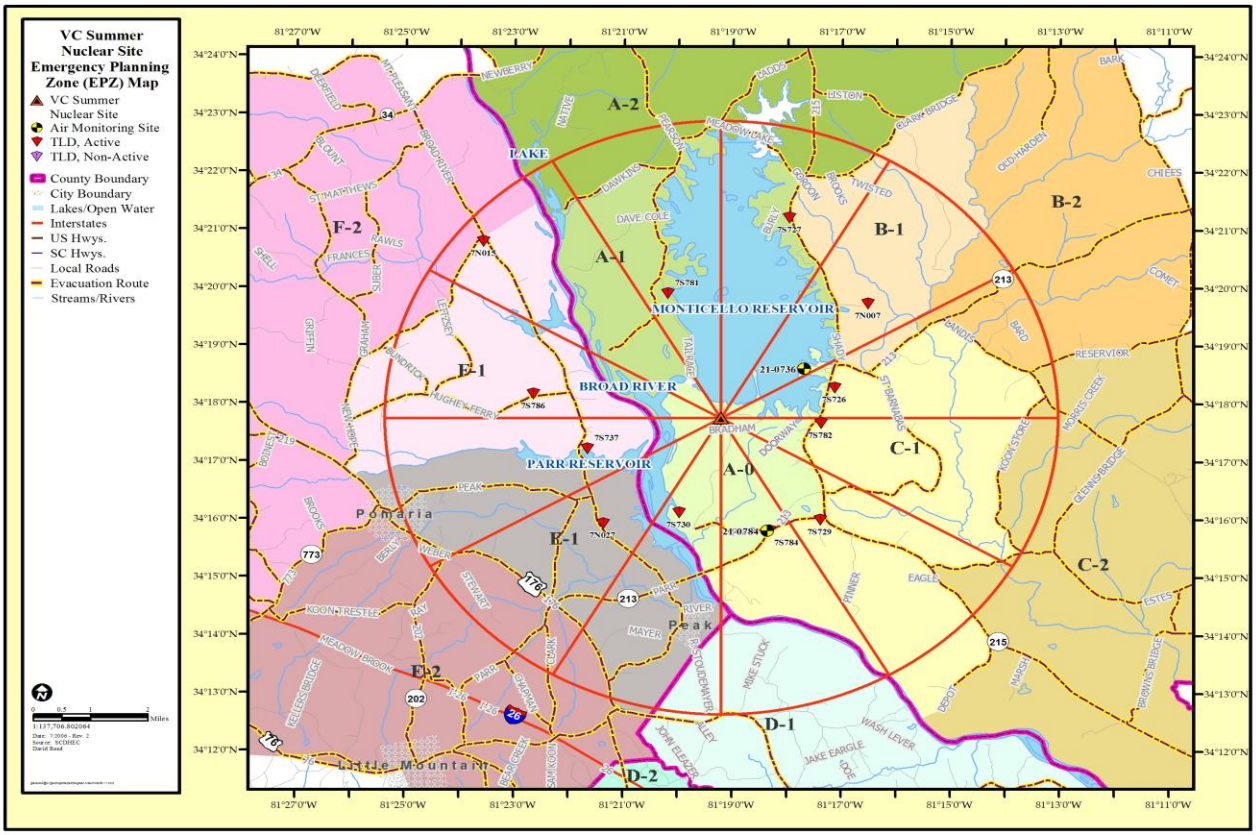



**Illustration 3 VCSNS Emergency Planning Zone Map with Air and TLD Sample Locations**

**Table 8.5 DHEC VCSNS Air Sampler Locations**

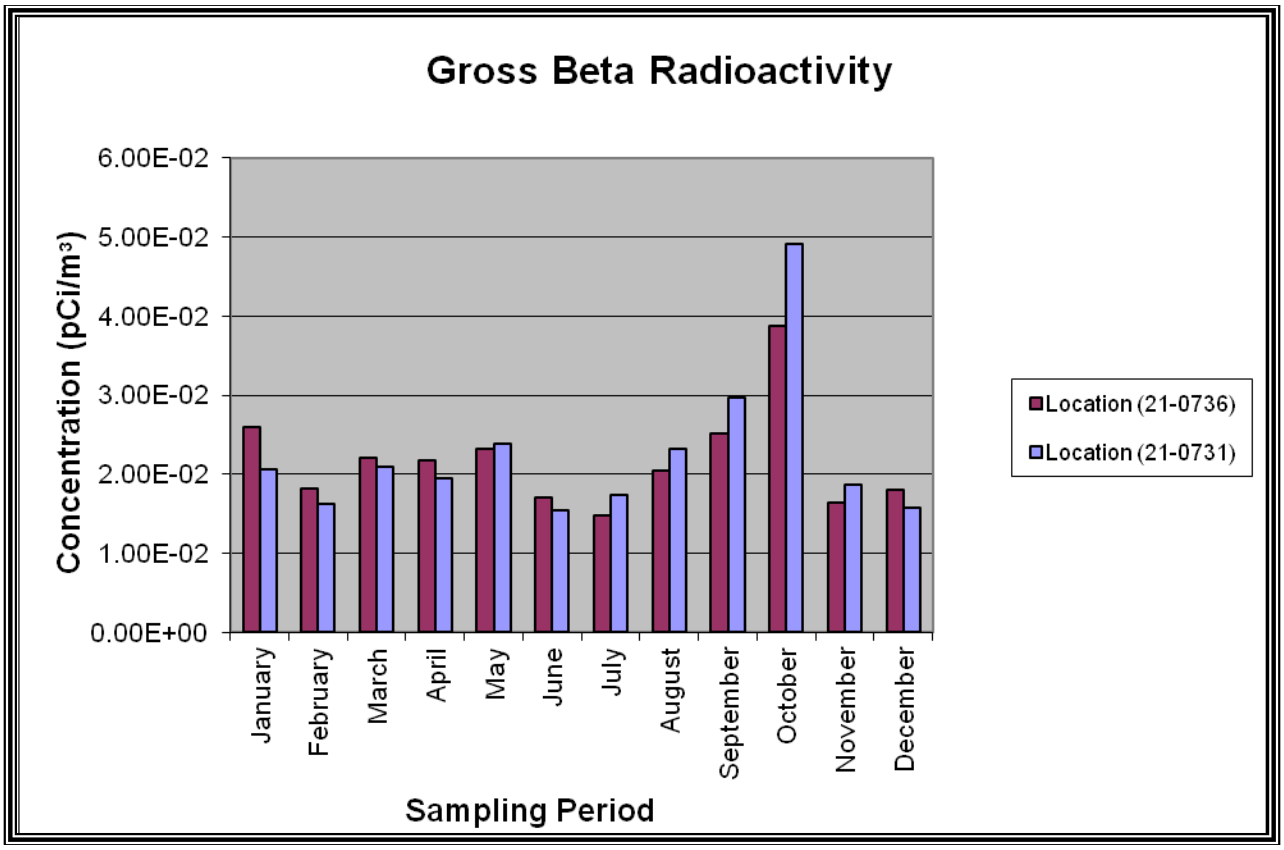
| Sample Location | Location Description |
|---|---|
| 21-0736 | Go North on SC #215, turn left on Fairfield Co #224, take second dirt road left to gate at end, park, walk past to air sampler (2.0 miles NE of VCSNS). |
| 21-0731 | Turn off SC215 onto Fairfield county #311 (plant entrance) toward VCSNS, turn left on first dirt road on left to fenced Garden Plot area (1.0 miles ESE of VCSNS |

**Table 8.6 DHEC VCSNS TLD Locations**

| | Sample Location | Location Description |
|---|---|---|
| | 7S781 | VCSNS North Gate |
| * | 7S727 | Monticello Community |
| * | 7N007 | On Rt 359 go 0.4 mi |
| * | 7S726 | Whitehall Elementary School |
| | 7S782 | Hwy. 215, 0.5 mile North of Lake Access Rd. |
| | 7S729 | CJ Shealy residence, Fairfield CR#213 just W of Junction with SC #215 on pole by flower bed. |
| | 7S784 | CR# 16 0.4 mile West of VCSNS Training Center |
| | 7S730 | Parr Village |
| * | 7N027 | On Rt.28 on utility pole at top of hill |
| | 7S737 | Cannon's Creek Landing |
| | 7S786 | CR# 9, 0.5 mile West of CR# 28 |
| * | 7N015 | On utility pole at inter. of Rt 97 & Rt 28 |

* No NRC/DHEC historical data for this TLD Location

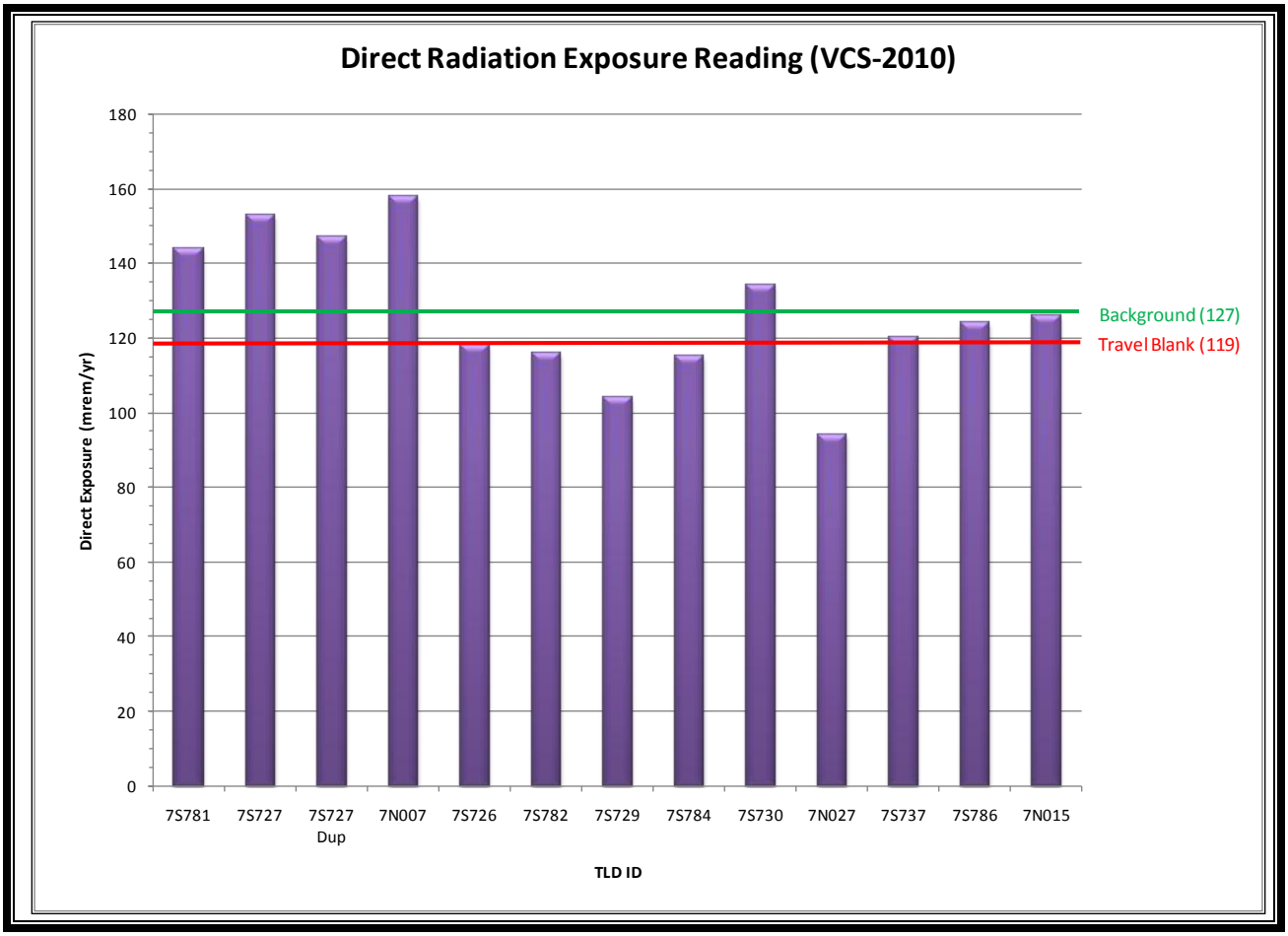
**Figure 8.5 DHEC Airborne Radiation Monitoring Data VCSNS**
Reporting Period: January 2010 to December 2010




**ENVIRONMENTAL CONSIDERATIONS: ANOMALIES/OUTLIERS**
*VCSNS—Air Samplers*

1. **Significant Increasing/Decreasing levels of radioactivity** : Gross Beta activity increases during the month of October(seasonal shift)
2. **Equipment Malfunctions:** NONE
3. **Weather Conditions:** NONE
4. **Deviation from historical and/or recent trends:** NONE
5. **Human errors (Calculation errors, sample handling errors):** NONE

**Figure 8.6 DHEC Direct Radiation Monitoring Data VCSNS**
Reporting Period: January 2010 to December 2010




## ENVIRONMENTAL CONSIDERATIONS: ANOMALIES/OUTLIERS

*VCSNS—Thermoluminescent Dosimeters (TLD)*

1. **Significant Increasing/Decreasing levels of radioactivity:** Five (5) TLD readings (7S781, 7S727, 7N007, 7S730 and 7N015) are above the control TLD exposure.
2. **Missing TLD(s):** NONE
3. **Weather Conditions:** NONE
4. **Deviation from historical and/or recent trends:** NONE
5. **Human errors (Calculation errors, sample handling errors):** NONE

## 8.4 CATAWBA NUCLEAR STATION

Catawba Nuclear Stations (CNS) is a two-unit facility located on the shore of Lake Wylie in York County, South Carolina, operated by Duke Energy. Each of the two units employs a pressurized water reactor nuclear steam supply system furnished by Westinghouse Electric Corporation. Each generating unit is designed to produce a net electrical output of approximately 1145 megawatts. Units 1 and 2 achieved initial criticality on January 7, 1985 and May 8, 1986, respectively.

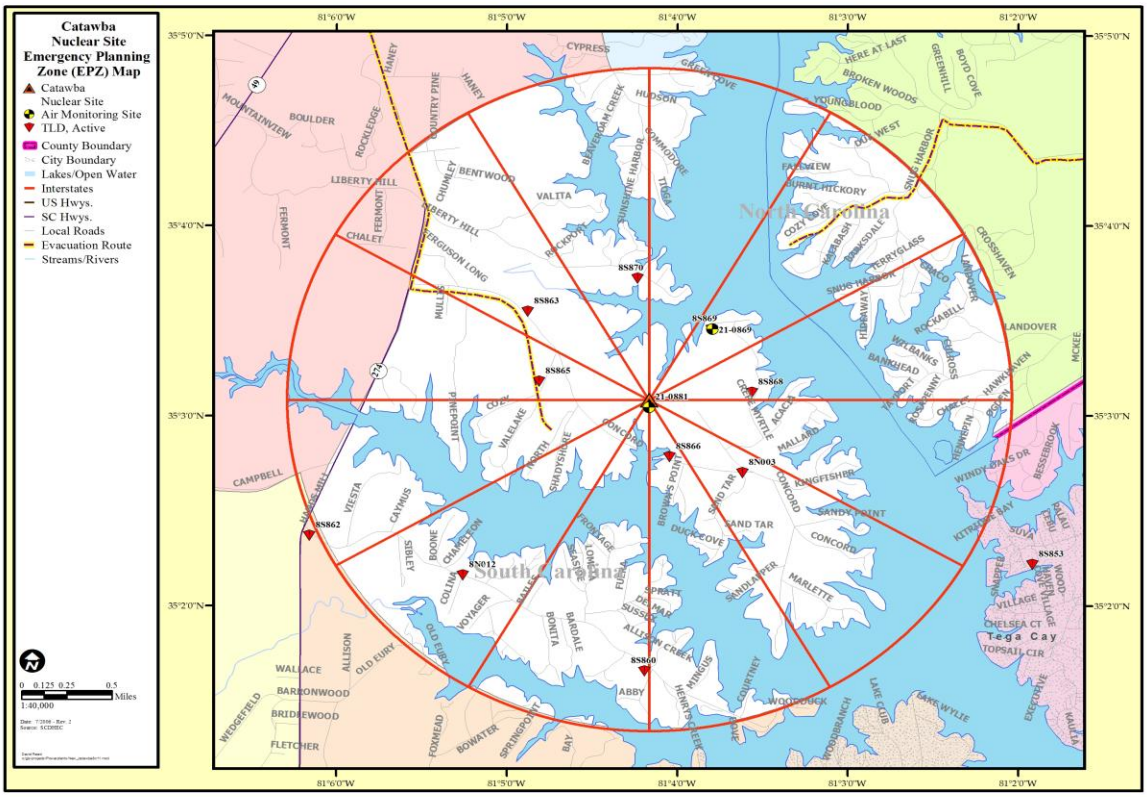



**Illustration 4 CNS Emergency Planning Zone Map with Air and TLD Sample Locations**

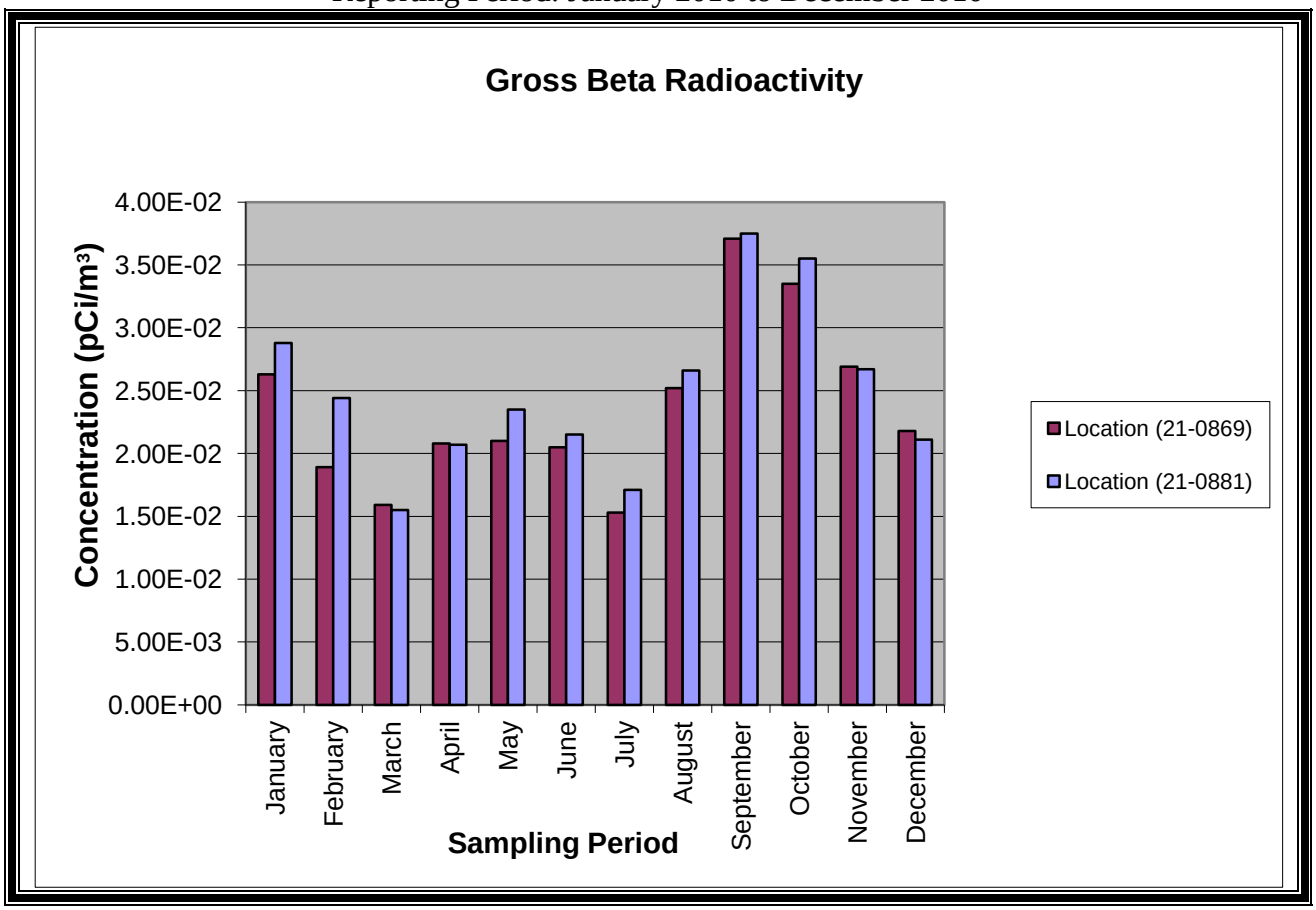
**Table 8.7 DHEC CNS Air Sampler Locations**

| Sample Location | Location Description |
|---|---|
| 21-0869 | Located at Catawba Environmental Monitoring Station on Bluebird Lane. |
| 21-0881 | At air sampler at Catawba Nuclear Station meteorlogical station, on site. |

**Table 8.8 DHEC CNS TLD Locations**

| | Sample Location | Location Description |
|---|---|---|
| | 8S870 | End of Liberty Hill Rd. |
| | 8S872 | At Buster Boyd Bridge on pole in T-Bones Parking Lot |
| | 8S869 | Located at Catawba Environmental. Monitoring Station on Bluebird Lane. |
| | 8S868 | On Paradise St. sign at intersection with Crepe Myrtle off old Concord Rd. |
| | 8S853 | On a tree right corner at Windjammer Park in Tega Cay. |
| | 8N003 | Concord & Sand Tar Rd's |
| | 8S866 | On discharge canal gate |
| | 8S860 | Located on utility pole 2.2 mi E. on junct with 274 on York Co. #1081 at Martha's Vineyard Road. |
| | 8N012 | Allison Creek Rd & Colina Rd |
| | 8S862 | Located on utility pole south of Allison Creek Church on SC 274 (2.2 miles SW of CNS). |
| | 8S865 | On guide wire at Vale Lake Road. |
| | 8S863 | Located at RR crossing sign west of junction of RR tracts and York Co. #1132. |

**Figure 8.7 DHEC Airborne Radiation Monitoring Data Catawba Nuclear Station (CNS)**
Reporting Period: January 2010 to December 2010

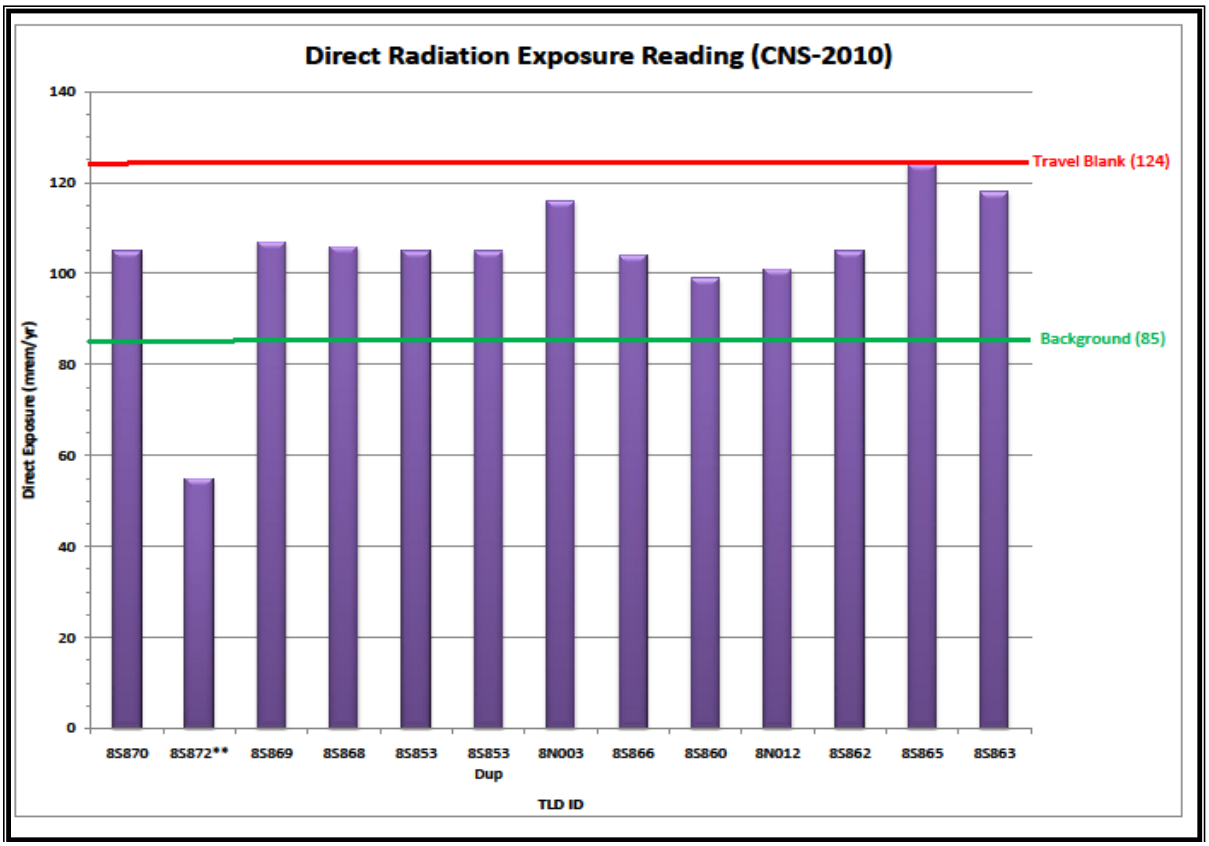



## ENVIRONMENTAL CONSIDERATIONS: ANOMALIES/OUTLIERS

*CNS—Air Samplers*

1. **Significant Increasing/Decreasing levels of radioactivity:** Gross Beta activity increases during the months of October(seasonal shift)
2. **Equipment Malfunctions:** NONE
3. **Weather Conditions:** NONE
4. **Deviation from historical and/or recent trends:** NONE
5. **Human errors (Calculation errors, sample handling errors):** NONE

**Figure 8.8 DHEC Direct Radiation Monitoring Data CNS**
Reporting Period: January 2010 to December 2010




## ENVIRONMENTAL CONSIDERATIONS: ANOMALIES/OUTLIERS

*CNS—Thermoluminescent Dosimeters (TLD)*

1. **Significant Increasing/Decreasing levels of radioactivity**: All TLDs were above background **2. Missing TLD(s): Sample ID 8S872** was found missing during 2nd and 4th Quarters 2010.
3. **Weather Conditions:** NONE
4. **Deviation from historical and/or recent trends:** NONE
5. **Human errors (Calculation errors, sample handling errors):** NONE

# 9.0 INTERPRETATION OF THE DHEC AIR SAMPLING NETWORK RESULTS

The air particulate samples are collected to determine alpha, beta, gamma-emitting radioactive materials concentrations. The environmental dosimetry (TLD) monitoring data are examined to measure the external exposure (dose) from environmental radiation levels as a secondary monitoring system. These results are compared to their respective data captured in previous DHEC Emergency Radiological Environmental Monitoring reports. A more detailed discussion of the results is presented in the following sections.

## 9.1 AIR PARTICULATE SAMPLING REGIME

*Radioanalysis of Air Particulate Samples*

Air Filters---- Gross Alpha and Gross Beta Analyses

The air filters are analyzed for gross alpha and gross beta radioactivity. Gross measurements are used as a method to screen samples for relative levels of radioactivity with no reference to the specific radionuclide source.

Gross Alpha Measurement

Based on the historical gross alpha data results, the trends are consistent and below gross beta levels. However, the NRC does not require monitoring of alpha radiation around commercial nuclear power plants. Therefore, the gross alpha data results are not presented in this report.

Gross Beta Measurement

Gross beta data are examined for central tendencies and measurement extremes for each SC commercial nuclear power plant. Graphical representations of the detailed gross beta

data results are displayed in Section 8 of this report. Historically, most of the observed environmental levels are below 0.03 $pCi/m^3$. This value simply notes the trend of the data collected from the emergency air particulate sampling network around the SC commercial nuclear facilities.

DHEC follows the guidance of the US Environmental Protection Agency (USEPA) for screening for gross beta radiation. The USEPA, through their Radnet program, compares nationwide sample results against certain screening levels for various media. A screening level is a guideline used by the USEPA to decide whether or not to determine the identity and activity of radionuclides in the sample and does not correspond to a regulatory limit. For gross beta radiation, a screening value of 1 $pCi/m^3$ is used. If this value is exceeded, a gamma analysis of the air filter is performed to identify the specific radionuclide source. None of the samples collected exceeded the 1 $pCi/m^3$ screening level.

Air Cartridges----Gamma Analysis

Gamma analysis is performed on samples from air cartridges from the sample locations around the SC commercial nuclear power plants. The specific radionuclides analyzed are Be-7, K-40, Mn-54, Co-58, Co-60, I-131, Cs-134, Cs-137, Ra-226, Ac-228, Th-234 and U-235. The gamma analysis results show the levels of these radionuclides, with the exception of K-40, are at background with no discernable trends deviating from past analyses. Thus, the results are less than the analytical Minimum Detectable Activity (MDA) after decay correction. MDA values are not presented in this report due to its variation per sample per radionuclide.

> Potassium-40 (K-40) appears periodically in the cartridge samples. Its presence in the samples can be contributed to natural processes of K-40 occurring in the environment. Based on the data trends of the K-40 detected in the samples and a review of literature, DHEC staffs believe that K-40 is not influenced by variations in environmental levels. Therefore, it is not considered further in this report.

Comparative Statistics of the Gross Beta Radioactivity Results

Statistical analysis is applied to the gross beta activity data results and presented in tabular form below in Tables 9.2 through 9.5. The tables show the average, minimum and maximum gross beta concentrations ($pCi/m^3$) for each reporting period. It is noted that each reporting period denotes a different sampling time span. Table 9.1 reflects the time span covered during each reporting period.

**Table 9.1 Sampling Time Span for EREM Program Reporting Periods**

| Reporting Periods | Actual Time Span |
|---|---|
| 2004-2006 | July 2004 through June 2006 |
| 2006-2007 | July 2006 through June 2007 |
| 2007-2008 | July 2007 through December 2008 |
| 2009 | January 2009 through December 2009 |
| 2010 | January 2010 through December 2010 |

All future reporting periods will reflect a standard calendar year.

**Table 9.2 Oconee Nuclear Station**

| Table 9.2 ONS Air Particulate Sampling Statistics | | | | | |
|---|---|---|---|---|---|
| **Gross Beta Concentration ( pCi/m$^3$ )** | **Station 21-0538** | | | | |
| | **2004-2006** | **2006-2007** | **2007-2008** | **2009** | **2010** |
| Average | 0.0233 | 0.0152 | 0.0172 | 0.0159 | 0.0226 |
| Maximum | 0.168 | 0.0228 | 0.0363 | 0.0293 | 0.0338 |
| Minimum | 0.007 | 0.0082 | 0.0083 | 0.00754 | 0.0149 |
| Stand. Dev. | 0.0353 | 0.0054 | 0.0067 | 0.00642 | 0.0065 |
| **Gross Beta Concentration ( pCi/m$^3$ )** | **Station 21-541/ Station 21-5781** | | | | |
| | **2004-2006** | **2006-2007** | **2007-2008** | **2009** | **2010** |
| Average | 0.0142 | 0.0162 | 0.0168 | 0.0233 | 0.0242 |
| Maximum | 0.0198 | 0.0226 | 0.0253 | 0.0518 | 0.0459 |
| Minimum | 0.007 | 0.0098 | 0.0050 | 0.0119 | 0.0150 |
| Stand. Dev. | 0.0031 | 0.0041 | 0.0048 | 0.0107 | 0.0087 |

From Table 9.2 above, gross beta concentrations for Oconee Nuclear Station during 2006-2010 are within reasonable limits relative to background radiation levels, based on the average concentrations. Thus, the average concentrations are under the normal environmental trend of 0.03 pCi/m$^3$. The maximum concentration level of 0.0459 pCi/m$^3$ was at sampling location 21-05781 . However, all the gross beta concentrations are well below the USEPA screening value of 1 pCi/m$^3$. Therefore, the airborne releases from the Oconee Nuclear Station are within normal

operating conditions and do not contribute to any elevated levels of radioactive particulates in the air.

**Table 9.3 HB Robinson Nuclear Station**

| Table 9.3 HBRNS Air Particulate Sampling Statistics | | | | | |
|---|---|---|---|---|---|
| **Gross Beta Concentration ( pCi/m$^3$ )** | **Station 21-0230** | | | | |
| | **2004-2006** | **2006-2007** | **2007-2008** | **2009** | **2010** |
| Average | 0.0170 | 0.0163 | 0.0198 | 0.0179 | 0.0242 |
| Maximum | 0.0238 | 0.0223 | 0.0364 | 0.0257 | 0.0342 |
| Minimum | 0.0086 | 0.0128 | 0.0102 | 0.0110 | 0.0012 |
| Stand. Dev. | 0.0037 | 0.0031 | 0.0058 | 0.0053 | 0.0170 |
| **Gross Beta Concentration ( pCi/m$^3$ )** | **Station 21-0238** | | | | |
| | **2004-2006** | **2006-2007** | **2007-2008** | **2009** | **2010** |
| Average | 0.0156 | 0.0132 | 0.0203 | 0.0180 | 0.0272 |
| Maximum | 0.0238 | 0.0207 | 0.0327 | 0.0251 | 0.0478 |
| Minimum | 0.0120 | 0.0073 | 0.0104 | 0.0113 | 0.0153 |
| Stand. Dev. | 0.0031 | 0.0035 | 0.0063 | 0.0054 | 0.0087 |

From Table 9.3 above, gross beta concentrations for HB Robinson Nuclear Station during 2006-2010 are within reasonable limits relative to background radiation levels, based on the average concentrations. Thus, the average concentrations are under the normal environmental trend of 0.03 pCi/m$^3$. The maximum concentration level of 0.0478 pCi/m$^3$ was at sampling location 21-0238. However, all the gross beta concentrations are well below the USEPA screening value of 1 pCi/m$^3$. Therefore, the airborne releases from the HB Robinson Nuclear Station are within normal operating conditions and do not contribute to any elevated levels of radioactive particulates in the air.

**Table 9.4 VC Summer Nuclear Station**

| Table 9.4 VCSNS Air Particulate Sampling Statistics | | | | | |
|---|---|---|---|---|---|
| **Gross Beta Concentration ( pCi/m$^3$ )** | **Station 21-0736** | | | | |
| | **2004-2006** | **2006-2007** | **2007-2008** | **2009** | **2010** |
| Average | 0.0121 | 0.0174 | 0.0172 | 0.0205 | 0.0218 |
| Maximum | 0.0232 | 0.0265 | 0.0270 | 0.0359 | 0.0387 |
| Minimum | 0.0006 | 0.0110 | 0.0084 | 0.0073 | 0.0148 |
| Stand. Dev. | 0.0061 | 0.0041 | 0.0044 | 0.0076 | 0.0064 |
| **Gross Beta Concentration ( pCi/m$^3$ )** | **Station21-0784/Station 21-0731** | | | | |
| | **2004-2006** | **2006-2007** | **2007-2008** | **2009** | **2010** |
| Average | 0.0173 | 0.0186 | 0.0153 | 0.0162 | 0.0225 |
| Maximum | 0.0245 | 0.0272 | 0.0207 | 0.0239 | 0.0491 |
| Minimum | 0.0130 | 0.0126 | 0.0075 | 0.0089 | 0.0154 |
| Stand. Dev. | 0.0023 | 0.0042 | 0.0034 | 0.0046 | 0.0093 |

From Table 9.4 above, gross beta concentrations for VC Summer Nuclear Station during 2006-2010 are within reasonable limits relative to background radiation levels, based on the average concentrations. Thus, the average concentrations are under the normal environmental trend of 0.03 pCi/m$^3$. The maximum concentration level of 0.0491 pCi/m$^3$ was at sampling location 21-0731. However, all the gross beta concentrations are well below the USEPA screening value of 1 pCi/m$^3$. Therefore, the airborne releases from the VC Summer Nuclear Station are within normal operating conditions and do not contribute to any elevated levels of radioactive particulates in the air.

**Table 9.5 Catawba Nuclear Station**

| Table 9.5 CNS Air Particulate Sampling Statistics | | | | | |
|---|---|---|---|---|---|
| **Gross Beta Concentration ( pCi/m$^3$ )** | **Station 21-0869** | | | | |
| | **2004-2006** | **2006-2007** | **2007-2008** | **2009** | **2010** |
| Average | 0.0146 | 0.0154 | 0.0168 | 0.0153 | 0.0236 |
| Maximum | 0.041 | 0.0215 | 0.0242 | 0.0193 | 0.0371 |
| Minimum | 0.00213 | 0.0119 | 0.0092 | 0.0080 | 0.0153 |
| Stand. Dev. | 0.00744 | 0.0032 | 0.0052 | 0.0036 | 0.0066 |
| **Gross Beta Concentration ( pCi/m$^3$ )** | **Station 21-0881** | | | | |
| | **2004-2006** | **2006-2007** | **2007-2008** | **2009** | **2010** |
| Average | 0.0155 | 0.0165 | 0.0199 | 0.0181 | 0.0249 |
| Maximum | 0.0587 | 0.0245 | 0.0248 | 0.0208 | 0.0375 |
| Minimum | 0.0070 | 0.0061 | 0.0105 | 0.0115 | 0.0155 |
| Stand. Dev. | 0.0277 | 0.0047 | 0.0035 | 0.0034 | 0.0067 |

From Table 9.5 above, gross beta concentrations for Catawba Nuclear Station during 2006-2010 are within reasonable limits relative to background radiation levels, based on the average concentrations. Thus, the average concentrations are under the normal environmental trend of 0.03 pCi/m$^3$. The maximum concentration level of 0.0375 pCi/m$^3$ was at sampling location 21-0881. However, all the gross beta concentrations are well below the USEPA screening value of 1 pCi/m$^3$. Therefore, the airborne releases from the Catawba Nuclear Station are within normal operating conditions and do not contribute to any elevated levels of radioactive particulates in the air.

## 9.2 DIRECT RADIATION (TLD) MONITORING REGIME

*Radioanalysis of Thermoluminescent Dosimeters*

Complimentary to the air particulate sampling regime, NREES measures environmental background radiation through a network of off-site TLDs placed about 1 meter above the ground in twelve (12) wind sectors to monitor for external dose. These devices measure direct, penetrating beta/gamma radiation originating from natural background, as well as any contribution from nuclear power station operations.

The scientific principle behind the function of TLDs is that when a crystals contained in the detector is exposed to any penetrating gamma radiation, the electrons are trapped in an excited state until the crystals are heated to a very high temperature. This released energy of excitation, is emitted in the form of visible light. These electrons remain in a high-energy state at normal ambient temperature until processing. The analytical laboratory of Global Dosimetry Solutions, Inc processes the TLDs. When processed, background exposures are not subtracted. Only element, reader and fade corrections are made.

The control TLD is maintained in a secure, unshielded area in the Bureau of Land and Waste Management facility, Stern Building, Columbia, SC. Average annual exposure rates (in milliroentgen /year) are determined to confirm that environmental radiation levels in the surrounding area are at background levels and that no adverse radiation exposure to the public occurs. The control comparison values will be used to assess current environmental radiation levels around each commercial nuclear power plant. The average annual control TLD dose values are 129 mR. Any exposure rate values above the control TLD value will be addressed in this report.

Comparative Statistics of the Direct Radiation (TLD) Results

Statistical analysis is also applied to the TLD monitoring data results and displayed in Table 9.6 below for further comparison.

**Table 9.6 Direct Radiation (TLD) Exposure Statistics**

| Exposure mar/year | Oconee TLD | HB Robinson TLD | VC Summer TLD | Catawba TLD |
|---|---|---|---|---|
| **2006-2007** | | | | |
| Minimum | 104 | 80 | 84 | 100 |
| Maximum | 152 | 116 | 152 | 124 |
| Average | 123 | 98 | 122 | 107 |
| Std Deviation | 13.55 | 11.75 | 20.71 | 8.38 |
| **2007-2008** | | | | |
| Minimum | 108 | 80 | 92 | 100 |
| Maximum | 140 | 116 | 152 | 120 |
| Average | 119 | 98 | 124 | 107 |
| Std Deviation | 9.24 | 11.37 | 17.84 | 6.57 |
| **2009** | | | | |
| Minimum | 111 | 83 | 94 | 88 |
| Maximum | 147 | 123 | 148 | 125 |
| Average | 123 | 101 | 125 | 108 |
| Std Deviation | 10.90 | 13.77 | 16.58 | 9.30 |
| **2010** | | | | |
| Minimum | 102 | 64* | 94 | 55** |
| Maximum | 139 | 123 | 158 | 124 |
| Average | 119 | 102 | 125 | 104 |
| Std Deviation | 10.48 | 15.63 | 17.84 | 17.03 |

*TLD **Sample 2S005** missing during the 2nd Quarter 2010
** TLD **Samples 8S872** missing during the 2nd and 4th Quarter 2010


*Thermoluminescent dosimeters( TLDs)*

## Oconee Nuclear Plant

Based on Table 9.6 above for Oconee Nuclear Station, the annual TLD exposure rates in the environment are consistent with the previous reporting periods. The average TLD exposure rate is 119 mrem/year and at a maximum exposure level of 139 mrem/yr. The average value is within bounds of the control TLD exposure of 129 mrem/yr. The maximum value exceeds the control TLD exposure. There are three TLD locations (5N031, 5S567, and 5S541) where the average readings mirrored the trends identified in previous reports. This suggests that this area contains higher concentrations levels of naturally occurring radioactive materials (NORMS) than that of the area where the control TLD is located. The NORMS issue for this area was confirmed in a groundwater screening initiative conducted by DHEC in 2008. DHEC continues to evaluate this area surrounding the Oconee Nuclear Station.

## HB Robinson Nuclear Plant

Based on Table 9.6 above for HB Robinson Nuclear Station, the annual TLD exposure levels in the environment are consistent with the previous reporting periods. The average TLD exposure rates are 102 mrem/yr with a maximum exposure level of 123 mrem/yr. These exposure levels are within the bounds of the control TLD exposure values of 129 mrem/yr.

## VC Summer Nuclear Station

Based on Table 9.6 above for VC Summer Nuclear Station, the annual TLD exposure rates in the environment are shown to be consistent with the previous reporting periods. The average TLD exposure levels are 125 mrem/yr with a maximum TLD exposure level of 158 mrem/yr. The average TLD exposure level is bounded by the control TLD exposure level of 129 mrem/yr; whereas the maximum TLD exposure level exceeds the control TLD exposure.

> The reason for the slightly elevated levels of radioactivity is unknown. The area surrounding the VC Summer facility is known to have naturally occurring radioactive materials (NORMS). The NORM material in this area presents no adverse exposure to the public.

## Catawba Nuclear Station

Based on Table 9.6 above for Catawba Nuclear Station, the annual TLD exposure levels in the environment are consistent with the previous reporting periods. The average TLD exposure levels are 104 mrem/yr with a maximum exposure level of 124 mrem/yr. These exposure levels are within the bounds of the control TLD exposure values of 129 mrem/yr.

### *Annual Dose Expectancy to the Public*

> In the U.S., the average annual dose expectancy from natural radiation background for the members of the public is an effective dose equivalent (EDE) of approximately 90 mrem/year from natural background radiation via cosmic and terrestrial sources. Comparing the exposure to health risk, the maximum TLD exposure rate is used to calculate the annual dose expected to be received by a person who occupies the sampling area. Using the bounding maximum TLD exposure level of 147 mR/yr observed over all the SC commercial nuclear power plants, the annual dose expectancy to the public is 90.2 mrem/year. This annual dose is bounded by the anticipated natural background expectancy.

The majority of the TLD exposures presented in this report are consistently lower than the control TLD exposure. Thus, TLD monitoring network indicated that there is no adverse impact of elevated radiation exposure to the public from the SC commercial nuclear stations.

## 10.0 CONCLUSIONS

***Discussion***

Air Particulate Sampling Regime

Results, when compared to the 2009 EREM Annual Report, indicate the air particulate sampling data, showed no indication of elevated radiation levels. Most of the gross beta particle activity falls below the natural trend (0.03 $pCi/m^3$) as determined from previous studies. When slight increases or decreases occur, equipment malfunctions and seasonal influences are considered to be the causes. All the gross beta concentrations are well below the USEPA screening value of 1 $pCi/m^3$. The results of the gamma analysis show no detections with the exception of naturally occurring Potassium-40 in most of the samples within expected range.

Direct Radiation (TLD) Monitoring Regime

Given more background references, the TLD readings reflected similar trends as previous years. TLD samples taken around the SC commercial nuclear stations do not indicate any elevated radiation exposure above the control TLD exposure value with the exception of a few results from TLDs located adjacent to the VC Summer and Oconee nuclear stations. The slight increases in radiation detected are unknown. However, consistence in TLD exposure levels for previous reporting years indicates the possibility of high concentrations of naturally occurring radioactive materials in these environments.

Overall Monitoring Network

The results of this EREM report for the period of January 2010 to December 2010 indicates that no public health or environmental radiological impact is detected. The findings of this report are also reflective of the last EREM report published in 2009. Therefore, the same conclusion can be drawn: All offsite samples show no analytical results attributable to nuclear power plant operations and data fluctuations are in the range of natural background radiation.

## 11.0 IMPROVEMENTS AND RECOMMENDATIONS

No new recommendations or improvements are identified for this reporting period.

## 12.0 REFERENCES

12.1 Hi-Q Environmental Products Co., Cabinet Mounted Pump Continuous Duty Constant Flow Air Sampling System, CMP Series, Rev. 1/8/04.

12.2 US Department of Energy (DOE), Grand Junction Office, *Moab Environmental Air Monitoring Sampling and Analysis Plan*, GJO-MOA 1.6-1, March 2003.

12.3 US Department of Energy (DOE), National Nuclear Security Administration, Nevada Operations Office, *FRMAC Monitoring and Analysis Manual: Radiation Monitoring and Sampling*, DOE/NV/11718-181-VOL.1, March 2002.

12.4 US Environmental Protection Agency, Manual of Protective Action Guides and Protective Actions for Nuclear Incidents, EPA-400-R-92-001, May 1992.

12.5 South Carolina Department of Health and Environmental Control (DHEC), *South Carolina Nuclear Facility Monitoring*, 1993 Annual Report, Bureau of EQC Laboratories, September 1994.

12.6 South Carolina Department of Health and Environmental Control (DHEC), *Section 3. Quality Assurance Procedures, Special Study Plans and Approvals* in Quality Assurance Management Plan For South Carolina Department Of Health And Environmental Control, Bureau of Environmental Services, Rev. 2, May 2006.

12.7 South Carolina Department of Health and Environmental Control (DHEC), *Section 19.6. Chain-of-Custody Procedures for Radiological Samples* in Quality Assurance Management Plan For South Carolina Department Of Health And Environmental Control, Bureau of Environmental Services, Rev. 2, May 2006.

12.8 South Carolina Department of Health and Environmental Control (DHEC), *Section 18. Radiological Monitoring* in Quality Assurance Management Plan For South Carolina Department Of Health And Environmental Control, Bureau of Environmental Services, Rev. 2, May 2006.

12.9 South Carolina Department of Health and Environmental Control (DHEC), *Section 4. Basic Training for New Employees Who Will Perform Field Activities* in Quality Assurance Management Plan For South Carolina Department Of Health And Environmental Control, Bureau of Environmental Services, Rev. 2, May 2006.

12.10 Duke Energy Corporation, *Annual Radiological Environmental Operating Report*, Catawba Nuclear Station, Unit 1 and Unit 2, May 2007.

12.11 Duke Energy Corporation, *Annual Radiological Environmental Operating Report 2006*, Oconee Nuclear Station, Unit 1 and Unit 2, May 2007.

12.12 Progress Energy Carolinas, Inc., *Annual Radiological Environmental Operating Report 2006*, HB Robinson Nuclear Station, Unit 2, May 2007.

12.13 Progress Energy Carolinas, Inc., *Annual Radiological Environmental Operating Report 2006*, VC Summer Nuclear Station, Unit 2, April 2007.

12.14 The Weather Underground, Inc., *History of Clemson, SC*, www.wunderground.com, accessed May 13, 2008.

12.15 The Weather Underground, Inc., *History of Columbia, SC*, www.wunderground.com, accessed May 13, 2008.

12.16 Eisenburg, Merril and Gesell, Thomas. Environmental Radioactivity: From Natural, Industrial and Military Sources, 4th Ed., Academic Press, 1997.

12.17 South Carolina Department of Health and Environmental Control (DHEC), Radiation Surveillance Data, Contract Data for Environmental Protection Agency, Division of Radiological Health, Report No. 72-B, December 1972.

12.18 South Carolina Department of Health and Environmental Control (DHEC), Radiation Surveillance Data, Contract Data for Environmental Protection Agency, Division of Radiological Health Report No. 72-4, June 1973.

12.19 South Carolina Department of Health and Environmental Control (DHEC), Radiation Surveillance Data, Contract Data for Environmental Protection Agency, Division of Radiological Health Report No. 72-1, September 1972.

12.20 South Carolina Department of Health and Environmental Control (DHEC), Radiation Surveillance Data, Contract Data for Environmental Protection Agency, Division of Radiological Health Report No. 72-3, March 1973.

12.21 South Carolina Department of Health and Environmental Control (DHEC), DHEC groundwater and surface water screening project for radioactive constituents around SC nuclear power plants, Oct 2008.

APPENDIX A

DHEC AIR SAMPLE MONITORING DATA RESULTS SUMMARY

**TABLE A-1. 2010 DHEC AIR PARTICLE SAMPLING DATA RESULTS SUMMARY**

| | Gross Beta Radioactivity ($pCi/m^3$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Oconee | | Catawba | | HB Robinson | | VC Summer | |
| **FREQUENCY** | (21-0538) | 21-0541/5781 | (21-0869) | (21-0881) | (21-0238) | (21-0230) | (21-0736) | (21-0731) |
| Jan-10 | 2.63E-02 | 2.10E-03 | 2.63E-02 | 2.88E-02 | 1.92E-02 | 2.20E-02 | 2.60E-02 | 2.06E-02 |
| Feb-10 | 1.60E-02 | <LLD | 1.89E-02 | 2.44E-02 | 1.86E-02 | 1.79E-02 | 1.81E-02 | 1.62E-02 |
| Mar-10 | 2.49E-02 | 2.48E-03 | 1.59E-02 | 1.55E-02 | 1.72E-02 | 1.48E-02 | 2.20E-02 | 2.10E-02 |
| Apr-10 | 2.22E-02 | 2.27E-03 | 2.08E-02 | 2.07E-02 | 2.10E-02 | 2.00E-02 | 2.18E-02 | 1.94E-02 |
| May-10 | 1.49E-02 | 1.41E-03 | 2.10E-02 | 2.35E-02 | 1.89E-02 | 3.81E-03 | 2.32E-02 | 2.38E-02 |
| Jun-10 | 1.94E-02 | 2.15E-03 | 2.05E-02 | 2.15E-02 | 2.16E-02 | 1.97E-02 | 1.71E-02 | 1.54E-02 |
| Jul-10 | 1.53E-02 | 2.03E-03 | 1.53E-02 | 1.71E-02 | 1.53E-02 | 1.48E-02 | 1.48E-02 | 1.74E-02 |
| Aug-10 | 2.32E-02 | 3.05E-03 | 2.52E-02 | 2.66E-02 | 2.63E-02 | 2.21E-02 | 2.05E-02 | 2.32E-02 |
| Sep-10 | 3.05E-02 | 2.55E-03 | 3.71E-02 | 3.75E-02 | 2.82E-02 | 3.42E-02 | 2.52E-02 | 2.97E-02 |
| Oct-10 | 3.38E-02 | 3.87E-03 | 3.35E-02 | 3.55E-02 | 4.78E-02 | 7.20E-02 | 3.87E-02 | 4.91E-02 |
| Nov-10 | 2.91E-02 | 2.15E-03 | 2.69E-02 | 2.67E-02 | 2.01E-02 | 3.19E-02 | 1.64E-02 | 1.87E-02 |
| Dec-10 | 1.56E-02 | 1.55E-03 | 2.18E-02 | 2.11E-02 | 1.78E-02 | 1.70E-02 | 1.80E-02 | 1.57E-02 |

APPENDIX B
DHEC DIRECT RADIATION (TLD) MONITORING DATA RESULTS SUMMARY

**TABLE B-1. 2010 DHEC DIRECT RADIATION (TLD) READINGS**

Average Annual Exposures

| Catawba | | VC Summer | | Oconee | | HB Robinson | |
|---|---|---|---|---|---|---|---|
| Location | mrem/yr | Location | mrem/yr | Location | mrem/yr | Location | mrem/yr |
| 8S870 | 105 | 7S781 | 144 | 5N031 | 107 | 2S003 | 96 |
| 8S872 | 55 | 7S727 | 150 | 5S567 | 136 | 2S240 | 104 |
| 8S869 | 107 | 7N007 | 158 | 5N009 | 113 | 2N007 | 114 |
| 8S868 | 106 | 7S726 | 118 | 5S566 | 102 | 2S238 | 99 |
| 8S853 | 105 | 7S782 | 116 | 5S535 | 117 | 2S292 | 86 |
| 8N003 | 116 | 7S729 | 104 | 5S534 | 122 | 2N003 | 106 |
| 8S866 | 104 | 7S784 | 115 | 5N014 | 116 | 2S004 | 123 |
| 8S860 | 99 | 7S730 | 134 | 5S541 | 139 | 2N024 | 111 |
| 8N012 | 101 | 7N027 | 94 | 5S532 | 116 | 2S006 | 112 |
| 8S862 | 105 | 7S737 | 120 | 5N025 | 117 | 2N026 | 96 |
| 8S865 | 124 | 7S786 | 124 | 5S544 | 116 | 2S005 | 64 |
| 8S863 | 118 | 7N015 | 126 | 5S538 | 122 | 2N029 | 113 |

No control exposures have been subtracted, and only element, reader and fade corrections have been made.